

Variability in the Opercular Structures of the Serpulid Polychaete *Hydroides elegans* (Haswell)

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Variations in the structure of both the functional and rudimentary opercula of the serpulid worm, *Hydroides elegans* are described. The possible causes for these observed differences in opercular structure are discussed. Such variability may lead to confusion in the identification of this species.

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INTRODUCTION

The serpulid polychaete *Hydroides elegans* (Haswell, 1883), occurs commonly in fouling communities throughout Australia and in other parts of the world. For many years this polychaete has been referred to in Australia as *Hydroides norvegica* Gunnerus 1768 (Allen, 1953; Dew and Wood, 1955; Wood, 1955; Dew, 1958; Wisely, 1958; Wood and Allen, 1958; Dew, 1959; Wisely, 1959; Blick and Wisely, 1964; Straughan, 1967; Russ and Wake, 1975; Russ, 1977; Dakin *et al.*, 1980; Moran, 1980). However, ten Hove (1974) has pointed out that *H. norvegica* is restricted in its distribution to Mediterranean and North Atlantic waters. Consequently species recorded as *Hydroides norvegica* in Australia should be referred to as *H. elegans* (ten Hove, pers. comm.). A description of the differences between these two species will not be given here since they have been discussed elsewhere in the literature (Zibrowius, 1971; Bornhold and Milliman, 1973; ten Hove, 1974).

The purpose of this paper is to describe variations in both the functional and rudimentary opercula of *H. elegans*, as these variations may lead to confusion in the identification of the species. The observations presented here are the result of studying approximately 800 specimens taken from settlement panels submerged for between 2 weeks and 15 months in Wollongong and Port Kembla Harbours. Specimens of each different type of opercular arrangement were identified by Dr H. ten Hove, University of Utrecht.

OPERCULAR VARIATIONS

Individuals of *Hydroides elegans* bear two opercula which normally are dissimilar in structure and size. The larger of the two opercula, termed the functional operculum (Schochet, 1973a), consists of two goblet-shaped structures, one sitting inside the other (Fig. 1). This double-cupped structure is attached to a long smooth pedicle. The lower or inferior cup (goblet) of this structure is dish-like in appearance and has 16-28 crenulations around its perimeter. Arising from its centre is the upper or superior cup which bears 15-18 spines. Each main spine, which often has a small spike protruding from its inner surface, possesses 2-4 lateral spines (Fig. 1). In harbours and areas where water turbidity is usually high these features may be hidden as the superior cup is often covered by a thick layer of sediment. The functional operculum may be attached to either the right or left branchial cirlet where it acts as a tube plug (Fig. 2a). It is

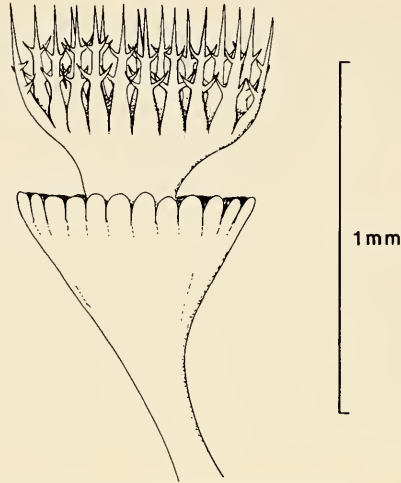


Fig. 1. Double-cupped functional operculum of *Hydroides elegans*.

thought also that the operculum is employed in a defensive capacity (Schochet, 1973a). The other operculum, termed the rudimentary operculum (Schochet, 1973a), is located on the side opposite to the functional operculum. It is a small bulbous structure of undifferentiated tissue which is attached to a short pedicle (Fig. 2a).

Although specimens of *Hydroides elegans* typically have only one functional operculum which is usually quite conspicuous, it is possible to find individuals which have two, fully developed, functional opercula. Dew (1958) found that individuals of *H. elegans* (identified as *H. norvegica* by Dew) may possess two double-cupped opercula, one of these having developed from the rudimentary operculum. In most instances this structure was noted to be shorter than the other functional operculum. Individuals with this type of opercular arrangement were found to occur in the fouling communities in both Port Kembla Harbour and Wollongong Harbour (Fig. 2b). In addition to observing that two double-cupped opercula may occur in the same tube, Dew (1958) also noted several other variations in the structure of the rudimentary operculum which corresponded to different stages of its development into a functional operculum.

Studies of individuals in Port Kembla and Wollongong Harbours have identified a further three different types of opercular arrangement in *H. elegans*, which result from changes in the structure of the rudimentary operculum and also the functional operculum. These three types have not been described before.

Several specimens were found which possessed a functional operculum that consisted of a single-cupped structure attached to a long pedicle (Fig. 2c). This opercular structure was very similar to the inferior cup of a normal functional operculum since it was dish-shaped and had approximately the same number of crenulations around its perimeter (16-25). Whereas in these specimens the rudimentary operculum was undeveloped (Fig. 2c), one individual was discovered to have two single-cupped opercula of dissimilar length in the one tube (Fig. 2d). In addition, a number of bi-operculate specimens of *Hydroides elegans* were found which contained a single-cupped operculum as well as a double-cupped operculum (Fig. 2e). Each of the opercula was associated with either the left or right branchial circlet. Usually in each individual tube the two opercular types were of different lengths. In some specimens the double-cupped operculum was longer whilst in others the single-cupped structure was found to be greater in length.

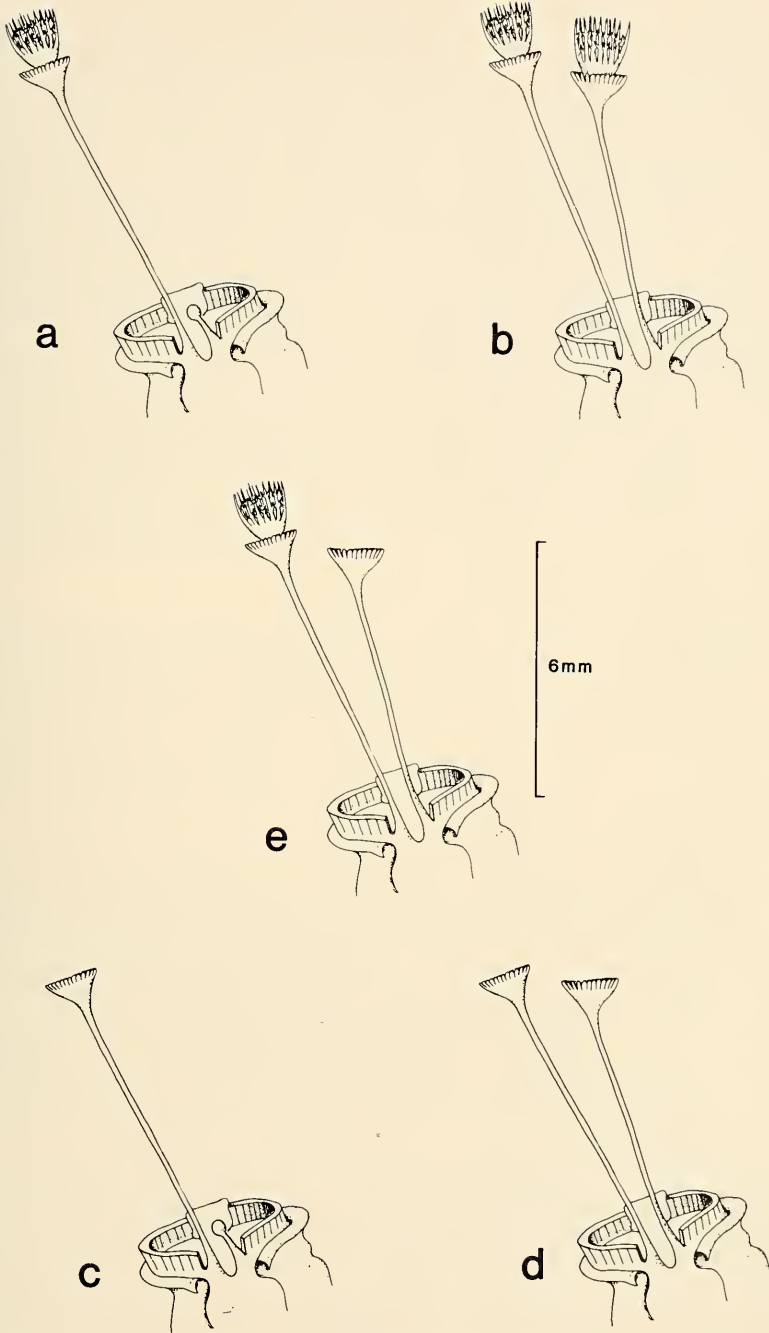


Fig. 2. Variability in the opercular structures of *Hydroides elegans*. Branchial filaments not shown. **a:** Functional operculum with single undeveloped rudimentary operculum. **b:** Two double-cupped functional opercula. **c:** Single-cupped functional operculum with undeveloped rudimentary operculum. **d:** Two single-cupped functional opercula. **e:** Double-cupped functional operculum with a single-cupped functional operculum.

DISCUSSION

A detailed account of opercular development has been given for *Hydroides dianthus* (Verrill 1873), (Zeleny, 1905, 1911; Schochet, 1973a) and *Hydroides norvegica* (Wisely, 1958). Initially, individuals of both these species are 'right-handed'. That is, the first functional operculum is attached to the right branchial circling. However, 'left-handed' as well as 'right-handed' individuals have been found in adult populations, suggesting that the functional operculum is able to change its position, from one branchial circling to the other, as the animal matures. This has been demonstrated for *Hydroides dianthus* (Zeleny, 1905; Schochet, 1973a); *Hydroides norvegica* (Wisely, 1958) and *Hydroides ezoensis* (Ichikawa and Takagaki, 1942). This is quite likely, since experiments have shown that amputation of the functional operculum results in the development of the rudimentary operculum (Ludwig and Ludwig, 1954; Schochet, 1973b). After the amputation, the functional operculum regenerates into a rudimentary structure, thus producing a reversal in the positions of both opercular types. This may occur several times during the lifetime of an individual (Schochet, 1973a). Coordination between the two types of opercula is thought to be governed by the functional structure. Puccia and Durante (1973) isolated a chemical substance which inhibited the development of the rudimentary operculum in specimens of *Hydroides norvegica*. The substance (5' adenosine monophosphate) was found to be in greatest quantities in the functional operculum suggesting that this structure was responsible for preventing the development of the rudimentary structure.

Such information accounts for the variability observed to occur amongst individuals with one functional operculum, unfortunately it does not explain the occurrence of individuals with two functional opercula. A number of theories have been put forward to account for the occurrence of such specimens. For example, Rioja (1919) considered that such animals were atavistic and had reverted to an early ancestral form which was symmetrical, however it is most likely that individuals with two functional opercula are a result of either natural ontogenetic processes or due to damage to the functional operculum.

Schochet (1973a) considered that these animals did not provide evidence of atavism but concluded that they are indicative of opercular reversal. According to Schochet, individuals with two functional opercula occur when the rudimentary operculum develops after overcoming the inhibitory effects of the functional operculum. The resultant symmetrical state is largely unstable and generally the more mature operculum is spontaneously cast off and the individual reverts to a single opercular state. Dew (1958) on the other hand, has proposed that if a rudimentary operculum developed in response to damage to a functional operculum and the functional operculum recovered from this injury, then the animal would eventually possess two double-cupped opercula.

The occurrence of individuals with single-cupped opercula cannot be accounted for by the theories described above. However, since this structure was noted to be very similar to the lower cup of a normal functional operculum the single cup structure is probably a functional operculum which has lost its superior cup or crown. It could also be a primary functional operculum (see Zeleny, 1905, 1911; Wisely, 1958; Schochet, 1973 a,b), which is a funnel-shaped structure formed very early in the development of the organism. However this is unlikely since the single-cupped structures were found in adult specimens.

Loss of the superior cup from a normal functional operculum could be a natural event and it may be shed just before the whole operculum is autotomized during opercular reversal. Also, since the superior cup is attached to the inferior cup by what

appears to be only a small, narrow base, then perhaps it is prone to being dislodged by natural physical disturbances, such as during times of storms and heavy seas.

Opercular structure in most instances, is a reliable taxonomic character to use when identifying serpulids. It is particularly useful when undertaking a census in which large numbers of serpulids are present, since it is a less time-consuming method of identification than employing features which require careful microscopic analysis. Unfortunately, problems may be encountered in the identification of *Hydroides elegans* because of the high degree of variability in its opercular structures. Indeed, specimens with single-cupped opercula could be confused with *Serpula* species, particularly *Serpula vermicularis* Linnaeus 1767. It has been suggested that *Hydroides* species are superficially similar to *Serpula* species except for the fact that they have a second crown on top of an otherwise funnel-shaped operculum (Lewis, 1982). Problems associated with the identification of individuals with single-cupped opercula may be resolved by considering a number of specimens, in order to determine whether they exhibit a diverse range of opercular structures. If this is the case, then the single-cupped individuals probably form part of a 'normal' population of *Hydroides elegans*. If considerable variation in opercular structure is not found amongst surrounding individuals then other more time-consuming taxonomic methods such as referring to the structure of setae, need to be undertaken.

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References

- ALLEN, F. E., 1953. — Distribution of marine invertebrates by ships. *Aust. J. Mar. Freshwat. Res.* 4: 307-316.
- BLICK, R. A. P., and WISELY, B., 1964. — Attachment rates of marine invertebrate larvae to raft plates at a Sydney Harbour site. *Aust. J. Sci.* 27: 84-85.
- BORNHOLD, B. D., and MILLIMAN, J. D., 1973. — Generic and environmental control of carbonate mineralogy in Serpulid (Polychaete) tubes. *J. Geol.* 81: 363-373.
- DAKIN, W. J., BENNETT, I., and POPE, E., 1980. — *Australian Seashores*. Sydney: Angus & Robertson.
- DEW, B., 1958. — Variations in the secondary operculum of the Australian representative of the polychaete worm *Hydroides norvegica* Gunnerus. *Proc. Roy. Zool. Soc. N.S.W.* 1956-57: 52-54.
- , 1959. — Serpulidae (Polychaeta) from Australia. *Rec. Aust. Mus.* 25: 19-56.
- , and WOOD, E. J. F., 1955. — Observations on periodicity in marine invertebrates. *Aust. J. Mar. Freshwat. Res.* 6: 469-479.
- HOVE, H. A. TEN. 1974. — Notes on *Hydroides elegans* (Haswell, 1883) and *Mercierella enigmatica* Fauvel, 1923, alien serpulid polychaetes introduced into the Netherlands. *Bull. Zool. Mus.* 4: 45-51.
- ICHIKAWA, A., and TAKAGAKI, N., 1942. — The reversible asymmetry in the opercula of *Hydroides ezoensis*. 1. Observations on the intact opercula. *J. Fac. Sci. Hokkaido Univ.* 8: 1-8.
- LEWIS, J. A., 1982. — A guide to the principal marine fouling organisms, with particular reference to Cockburn Sound, W.A. Report MRL-R-858. Melbourne: Dept of Defence, Materials Research Laboratories.
- LUDWIG, W., and LUDWIG, H. W., 1954. — Untersuchungen zur kompensatorischen Regeneration an *Hydroides norvegica*. *Roux' Archiv.* 147: 250-287.
- MORAN, P. J., 1980. — Natural physical disturbance and predation: their importance in structuring a marine sessile community. *Aust. J. Ecol.* 5: 193-200.
- PUCCIA, E., and DURANTE, M., 1973. — The compensatory regeneration of the operculum of *Hydroides norvegica*: Identification of the inhibiting substance. *J. Exp. Zool.* 184: 1-6.
- RIOJA, E., 1919. — Una curiosa anomalia del *Hydroides norvegica* Gunn. y algunas consideraciones acerca de la filogenia de los serpulidos. *Bol. Real Soc. esp. Hist. nat.* 19: 445-449.

- RUSS, G. R., 1977. — A comparison of the marine fouling occurring at the two principal Australian naval dockyards. Report MRL-R-688. Maribyrnong, Australia: Dept of Defence.
- , and WAKE, L. V., 1975. — A manual of the principal Australian marine fouling organisms. Report MRL-R-644, Maribyrnong, Australia: Dept of Defence.
- SCHOCHET, J., 1973a. — Opercular regulation in the polychaete *Hydroides dianthus* (Verrill, 1873). I. Opercular ontogeny, distribution and flux. *Biol. Bull.* 144: 400-420.
- , 1973b. — Opercular regulation in the polychaete *Hydroides dianthus* (Verrill, 1873). II. Control of opercular regulation. *J. Exp. Zool.* 184: 259-280.
- STRAUGHAN, D., 1967. — Marine serpulidae (Annelida: Polychaeta) of eastern Queensland and New South Wales. *Aust. J. Zool.* 15: 201-261.
- WISELY, B., 1958. — The development and settling of a serpulid worm *Hydroides norvegica* Gunnerus (Polychaeta). *Aust. J. Mar. Freshwat. Res.* 9: 351-361.
- , 1959. — Factors influencing the settling of the principal marine fouling organisms in Sydney Harbour. *Aust. J. Mar. Freshwat. Res.* 10: 30-44.
- WOOD, E. J. F., 1955. — Effect of temperature and rate of flow on some marine fouling organisms. *Aust. J. Sci.* 18: 34-37.
- , and ALLEN, F. E., 1958. — Common marine fouling organisms of Australian waters. Melbourne: Dept of Navy.
- ZELENY, C., 1905. — Compensatory regulation. *J. Exp. Zool.* 5: 1-102.
- , 1911. — Experiments on the control of asymmetry in the development of the serpulid, *Hydroides dianthus*. *J. Morphol.* 22: 927-944.
- ZIBROWIUS, H., 1971. — Les espèces Méditerranéennes du genre *Hydroides* (Polychaeta Serpulidae). Remarques sur le prétendu polymorphisme de *Hydroides uncinata*. *Tethys* 2: 691-746.